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INSTRUCTION MANUAL

TOUCH-TEST 20/21

DIGITAL MULTIMETER

NON-LINEAR SYSTEMS, INC.
DEL MAR, CALIFORNIA

NOTICE

The instructions in this manual also fully apply to the TT-21 and TT-21B Digital Multimeters which are functionally identical to the TT-20 and TT-20B. The difference between the instruments is the readout; the TT-21 and TT-21B provide a liquid-crystal display instead of an LED display. A schematic diagram of the Switch, Display, Main Board and Power Supply Assemblies for the TT-21 and TT-21B is included at the rear of this manual.

Printed in the United States of America

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SECTION I

INTRODUCTION AND DESCRIPTION

1-1. INTRODUCTION.

1-2. This manual provides information for the familiarization, operation and maintenance of the Touch/Test 20 (TT-20) Digital Multimeter. The TT-20 is a new generation of digital multimeter which, by incorporating major new technology, advances the state-of-the-art in digital instrumentation. The TT-20 is the first digital test instrument with fast, convenient and modern touch selection of functions, ranges and even on-off power control.

1-3. Before operating your TT-20 multimeter you should carefully read the specifications to become acquainted with the input limits of the many functions the instrument provides. You should also carefully read the operating section to ensure your knowledge of input connections, offset adjustments and operating controls.

1-4. DESCRIPTION.

1-5. The NLS Model Touch/Test 20 is a 3-1/2-digit digital multimeter with the capability of measuring 10 parameters including 20 functions and 44 ranges. In addition, it features touch selection and annunciator lamp indication of control settings which include function, range and on-off power. The result is a clean, well organized front panel for easy comprehension and fast error-free operation.

1-6. Parameters the Touch/Test 20 will measure are:

AC Voltage	DC Voltage
AC Current	DC Current
Resistance	Capacitance
Conductance	Continuity
Temperature	Diode Test

1-7. AC VOLTAGE.

1-8. There are two AC voltage functions. AC volts and AC millivolts. Each function has three ranges. Measurements from 10 microvolts to 750 VRMS are possible; accuracy is

±0.5%. Input impedance is 10 megohms. The AC/DC converter employed is average-responding, calibrated in RMS AC units.

1-9. DC VOLTAGE.

1-10. DC voltage functions are volts and millivolts. Six ranges cover the span from 10 microvolts to 1000 volts DC; accuracy is ±0.2%. Input impedance is 10 megohms. The A/D converter in the TT-20 employs an integrating technique which results in high noise rejection and excellent stability, and minimizes the number of critical components.

1-11. AC CURRENT.

1-12. AC current functions are amperes and milliamperes. Four ranges allow current measurements from 10 microamperes to 10 amperes. The current functions have a separate front panel input jack and the voltage burden for current measurement is less than 250 millivolts. Accuracy is ±1.5%.

1-13. DC CURRENT.

1-14. Amperes, milliamperes and microamperes are the DC current functions. Combined, they provide seven ranges which cover the span from 0.01 microampere to 10 amperes. Accuracy is ±1%. A separate input jack located on the front panel is used for all current functions. The voltage burden for current is 250 millivolts.

1-15. RESISTANCE.

1-16. The three resistance functions are megohms, kilohms and ohms. They provide seven resistance ranges which permit measurements from 10 milliohms to 20 megohms. For megohms, kilohms and ohms accuracy is ±0.25%. Test current is 100 nanoamperes, 10 microamperes or 1 milliampere, depending upon the range. Test voltage is two volts for megohms and less than 0.2 volts for kilohms and ohms. In-circuit resistance measurements can be performed on all but the 20 megohm range. "Low Ohms" measurements are intrinsic to the instrument.

1-17. DIODE TEST.

1-18. Diode test provides a simple quantitative means of

checking diode and transistor junctions in both conducting and nonconducting directions. Whenever the TT-20 is connected to a diode in the forward direction, a constant one milliampere is passed through the diode and the voltage drop across the diode is read in millivolts with an accuracy of ±0.2%. Reversing the leads to measure the backwards or nonconducting direction in almost every case results in an overload indication on the meter. The exception may be some extremely high-power devices which will show a much higher reading in the reverse direction than the forward direction. The data sheet for a particular diode or transistor will indicate the reading to be expected.

1-19. CONDUCTANCE.

1-20. The conductance function has two ranges which cover the span from 0.01 nanosiemens to 199.9 nanosiemens. Accuracy is ±0.2%. Test voltage is 10 volts. The conductance function is useful to users who have the need to work in conductance units and find them convenient. The biggest advantage of conductance readings is that they employ the most uncomplicated method for measuring insulation resistance. The conductance measurement can also be used to test the leakage of capacitors and semiconductors provided the 10 volts applied to the component does not exceed their ratings.

1-21. CONTINUITY.

1-22. The continuity function provides the capability of checking conductors and solder joints for shorts and open circuits, audibly. An audible indication can be perceived by listening to the pitch of the tone generated by the Touch/Test 20 in the continuity mode. The pitch varies from low to high as the resistance being measured increases. When the full scale reading is exceeded, the tone ceases. The continuity function duplicates the ohms function in every respect and adds the audible output for ease of operation. The operator senses the reading with his ears while using his eyes and hands to position the test probes.

1-23. TEMPERATURE.

1-24. The TT-20 has two temperature functions, one for measuring Celsius from -40 to +150 degrees; the other for measuring Fahrenheit from -40 to +302 degrees. Resolution

is one degree. Accuracy is ±3°C. A semiconductor temperature probe is included with each instrument. Allow time for the probe to reach a stable temperature.

1-25. CAPACITANCE.

1-26. Capacitance functions include microfarads, nanofarads and picofarads which cover the range of capacitance from one picofarad to 200 microfarads. There are two ranges for the microfarad function. Test voltage is 0.2 volts, while accuracy is ±1%. Nanofarads are covered in three ranges with a test voltage of 0.2 volts and an accuracy of ±1%. Picofarad is a one-range function. Test voltage for the 2000 picofarad range is 0.2 volts and accuracy is ±1%. In-circuit capacitance measurements are possible on all ranges but the lowest as errors may result from test lead capacitance and line voltage pickup.

1-27. A component test adapter is supplied with each instrument. Testing of parts with radial leads is accurately accomplished using the adapter, and increased accuracy for picofarad values results since lead capacitance is eliminated.

1-28. CONTROLS AND INDICATORS.

1-29. Front-panel controls consist entirely of the convenient touch-type with annunciator indication. On-off power is indicated by the presence of the LED readout display. On the right side of the panel is an array of 5 x 4 function symbols. They are touch controls for selecting any of the 20 functions the instrument will measure. An LED indicator identifies the symbol for function selected. A large, bright LED numerical readout is provided with numerals 9/16" high. Decimal points are positioned by touch range selection controls. Logic circuits are provided so that only valid function and range combinations can be selected. Non-valid selections automatically revert to a valid combination. Overload indication appears as a display of the numeral "1" in the left-most decade while all the other decades are blank whenever the full scale range is exceeded by the input.

1-30. GENERAL.

1-31. The TT-20 is packaged in an attractive, scuff-resistant case with a tilt stand for bench viewing. Well arranged, easy-to-use touch controls are located on the front panel along with the large LED readout. Input jacks and test leads are manufactured for safe operation at high voltage inputs. Internally the instrument features modular plug-in construction. Modules carry complete functions so that optimum maintainability and time-to-repair are insured.

1-32. Overload protection is 1000 volts peak for all functions. One fuse is utilized for the 2A and low current ranges. Otherwise, modern electronic protection is used throughout, eliminating the need to change fuses.

1-33. Specifications are met at 23°C ±5°C. Temperature coefficient is typically 100 parts-per-million over the temperature range of 0 to +40 degrees Celsius.

1-34. The TT-20 measures 2.9" H x 6.4" W x 7.5" D. It weighs less than 3 pounds without batteries. The instrument incorporates two MOS-LSI integrated circuits, an integrating A-to-D converter and a CPU (microprocessor). Highly stable and accurate operational amplifiers are used for signal conditioning. Glass epoxy PC boards are used throughout. Stable, low temperature and voltage coefficient resistors provide outstanding accuracy and long term stability. Hard, dry relay contact-closures are used for switching critical voltages and currents in order to achieve the greatest precision for all functions.

1-35. Optional accessories include a 45 kV high voltage probe, and a leather carrying case. The carrying case has a strap for wearing the instrument on the neck or shoulder as well as a loop for carrying it on the belt.

1-36. Accessories which are included with the instrument are safety test leads, a temperature probe and a component test adapter.

1-37. There are two differently powered versions of the TT-20. The standard version is battery or line powered. Three lead-acid D cells and a battery charger are included. By ordering the instrument without batteries, a battery bypass is used for operation from the line only. Battery life

is typically six hours. Battery charging time is approximately 16 hours with the meter not operating.

1-38. SPECIFICATIONS.

Accuracy and Resolution: See table 1-1.

Range Selection: Touch Control

Polarity Selection: Automatic

Decimal Point: Touch Control

Display: 9/16" high LED

Overload Indication: Left-most digit is the numeral "1"; the remaining digits are blank. Appropriate polarity and decimal point are displayed.

Overload Protection: For current input: 10 A, AC or DC. All other ranges and functions protected to 1000V peak for 30 seconds by automatic electronic protection circuits.

Operating Temperature: 0 to +40°C.

Temperature Coefficient: Typically 100 parts-per-million-per-degree C on all ranges and functions.

Size: 2.9" H x 6.4" W x 7.5" D

Weight: Less than 3 lbs without batteries

Power:

(1) Three type-D lead-acid cells with six hours discharge time and 16 hours recharge time. Will also operate from AC line. Batteries and charger included.

(2) Line operation only. Charger included but without batteries.

(3) 115 VAC charger is standard. For 230 VAC operation, a 230 VAC charger must be specified.

Table 1-1. Accuracy and Resolution (Sheet 1 of 2)

FUNCTION	FULL SCALE	RESOLUTION	ACCURACY
A ⎓	10.00 A	10 mA	±(1% Rdg + 1 digit)
mA ⎓	19.99 mA	10 µA	±(1% Rdg + 1 digit)
	199.9 mA	100 µA	
	1999. mA	1 mA	
µA ⎓	19.99 µA	10 nA	±(1% Rdg + 1 digit)
	199.9 µA	100 nA	
	1999. µA	1 µA	
A ~	10.00 A	10 mA	±(1.5% Rdg + 2 digits)*
mA ~	19.99 mA	10 µA	±(1.5% Rdg + 2 digits)*
	199.9 mA	100 µA	±(1.5% Rdg + 20 digits)*
	1999. mA	1 mA	±(1.5% Rdg + 2 digits)*
V ⎓	19.99 V	10 mV	±(0.2% Rdg + 1 digit)
	199.9 V	100 mV	
	1000. V	1 V	
mV ⎓	19.99 mV	10 µV	±(0.2% Rdg + 1 digit)
	199.9 mV	100 µV	
	1999. mV	1 mV	
→|	1999. mV	1 mV	±(0.2% Rdg + 1 digit)†
V ~	19.99 V	10 mV	±(0.5% Rdg + 20 digits)*
	199.9 V	100 mV	±(0.5% Rdg + 2 digits)*
	750. V	1 V	±(0.5% Rdg + 1 digit)*
mV ~	19.99 mV	10 µV	±(0.5% Rdg + 20 digits)*
	199.9 mV	100 µV	±(0.5% Rdg + 2 digits)*
	1999. mV	1 mV	±(0.5% Rdg + 1 digit)*
nS	19.99 nS	10 pS	±(0.2% Rdg + 2 digits)
	199.9 nS	100 pS	±(0.2% Rdg + 2 digits)
MΩ	19.99 MΩ	10 kΩ	±(0.25% Rdg + 1 digit)†
kΩ	19.99 kΩ	10 Ω	±(0.25% Rdg + 1 digit)†
	199.9 kΩ	100 Ω	
	1999. kΩ	1 kΩ	

Table 1-1. Accuracy and Resolution (Sheet 2 of 2)

FUNCTION	FULL SCALE	RESOLUTION	ACCURACY
Ω	19.99 Ω 199.9 Ω 1999. Ω	10 mΩ 100 mΩ 1 Ω	±(0.25% Rdg + 1 digit)†
	19.99 Ω 199.9 Ω 1999. Ω	10 mΩ 100 mΩ 1 Ω	±(0.25% Rdg + 1 digit)†
°F	302. °F	1 °F	±(5°F -40°F to +302°F)
°C	150. °C	1 °C	±(3°C -40°C to +150°C)
µF	19.99 µF 199.9 µF	10 nF 100 nF	±(1% of Full Scale) ±(1% of Full Scale)
nF	19.99 nF 199.9 nF 1999. nF	10 pF 100 pF 1 nF	±(1% of Full Scale)
pF	1999. pF	1 pF	±(1% of Full Scale)

NOTES:

*Frequency Response: 50 Hz to 10 kHz

†Test Current:

Diode Test - 1 mA ±2%   19.99 MΩ - 100 nA

19.99 kΩ - 10 µA   19.99 Ω - 1 mA
199.9 kΩ - 100 nA   199.9 Ω - 1 mA
1999. kΩ - 100 nA   1999. Ω - 10 µA

Temperature range for all accuracies - 18°C to 28°C
(Some offset adjustment may be required.)

SECTION II

OPERATION

2-1. INTRODUCTION.

2-2. This section provides a description of the TT-20's operating controls, input connections, power sources, fusing, offset controls and accessories. It also provides information on care of batteries, offset adjustments, overload indication, down-ranging data and measurement procedures for the many functions it offers.

2-3. OPERATING CONTROLS.

2-4. The front panel of the instrument contains 25 pressure-sensitive switches, each of which are activated by merely touching with a fingertip. Twenty of these switches are for function selection, three are for range selection (decimal position) and the remaining two are for power on-off control. Table 2-1 provides detailed information on the function switches and figure 2-1 displays front and rear views of the instrument.

2-5. INPUT CONNECTIONS.

2-6. Three input jacks are located on the front panel; they are labeled INPUT, COMMON and CURRENT. For all measurements except current, signal inputs are applied to the INPUT and COMMON jacks. For current measurement, signal high is applied to the CURRENT jack and signal low to the COMMON jack.

2-7. POWER SOURCE (TT-20B).

2-8. The TT-20B has three internal, rechargeable lead-acid type-D cells. A charger unit for the batteries is included with the instrument and is connected through an input jack located on the rear panel. Battery discharge time under normal operating conditions is six hours; battery recharge time is 16 hours with the instrument not operating. With the charger unit plugged into the instrument and into an appropriate line power source, operating time is not limited. The standard charger unit provided is for 115 VAC operation; 230 VAC charger units are available.

TABLE 2-1. Function Switches

SYMBOL	FUNCTION	MEASURES
A⎓	Amperes DC	Current
mA⎓	Milliamperes DC	Current
µA⎓	Microamperes DC	Current
A~	Amperes AC	Current
mA~	Milliamperes AC	Current
V⎓	Volts DC	Voltage
mV⎓	Millivolts DC	Voltage
─▷├─	Diode Test	Millivolts
V~	Volts AC	Voltage
mV~	Millivolts AC	Voltage
nS	Nanosiemens	Conductance
MΩ	Megohms	Resistance
kΩ	Kilohms	Resistance
Ω	Ohms	Resistance
(•)))	Continuity (Audible)	Resistance
°F	Degrees Fahrenheit	Temperature
°C	Degrees Celsius	Temperature
µF	Microfarads	Capacitance
nF	Nanofarads	Capacitance
pF	Picofarads	Capacitance

Figure 2-1. Front and Rear Views

2-9. POWER SOURCE (TT-20).

2-10. The TT-20 does not contain batteries and operates only from line power. The same charger unit that operates the TT-20B provides power for the TT-20 (a battery bypass circuit is internally connected). As with the TT-20B, 115 VAC operation is standard; 230 VAC must be specified.

2-11. FUSES.

2-12. Two two-ampere fuses are installed within the instrument. One is for protection from excessive current drain from the batteries and the other for protection from excessive input current in the microampere and milliampere ranges.

2-13. OFFSET CONTROLS.

2-14. Five screwdriver or fingertip adjustment offset potentiometers are located on the rear panel. They are provided to zero the instrument in the millivolt (DC), picofarad, nanosiemen, kilohm and ohm functions.

2-15. ACCESSORIES.

2-16. Accessories include two test leads, a component test adapter and a temperature probe.

2-17. TEST LEADS. The test leads, one red, the other black, include bananna plugs for instrument-connection and test probes for input-source connection.

2-18. COMPONENT TEST ADAPTER. The component test adapter is provided to facilitate component test. It is inserted into the INPUT and COMMON jacks. The leads of the component under test are inserted into the adapter for hands-free operation. For offset adjustments requiring a shorted input, a small jumper wire may be inserted to connect the opposite ends of the adapter to effect the shorted condition.

2-19. TEMPERATURE PROBE. The temperature probe consists of a 60-inch teflon-insulated cable with a dual bananna plug for instrument-connection and a transistor sensor for temperature-source contact.

2-20. CARE OF BATTERIES (TT-20B).

2-21. With proper care, the batteries within the TT-20B will give years of service with little degradation of capacity. To preserve the capacity of the batteries (the ability to retain a full charge), follow the instructions set forth below:

a. When operating from line voltage, keep the charger plugged into the meter and into an active power outlet at all times. The batteries will reach their maximum charge overnight when the power switch is off. Keeping the batteries as near to full charge as possible will help preserve their operating life. If the instrument is run from line voltage continuously, the batteries will level out at approximately one-half full charge.

b. When it is desired to operate the TT-20B from the batteries alone, first be sure that they are fully charged so that maximum operating life can be obtained. If not fully charged, plug the charger into the rear of the meter and into an active power outlet. Leave the power switch off until you are ready to use the instrument. The batteries will reach their maximum charge in 16 hours. Leaving the batteries on charge for a longer period of time will not harm them. The meter's charging circuitry will automatically cut off when the batteries reach full charge and will keep them at full charge.

c. At full charge, the batteries will provide six hours of continuous operation. Take advantage of the instrument's short warm-up time and save the batteries - shut it off when you are not actually using it.

d. When the batteries have run down, the readout display will go out. When this occurs, the meter will automatically shut itself off. Put the meter back on charge as soon as possible. It is better to give them a full charge before using the instrument again; this will help to preserve their capacity.

2-22. OFFSET ADJUSTMENT FOR A TRUE ZERO.

2-23. In performing the offset adjustments set forth in these procedures, a true zero may be obtained as follows:

NOTE

In making the offset adjustments, the same input conditions must exist as when actually performing the measurement tasks, i.e., using the same input leads or the component adapter.

a. Adjust the potentiometer to obtain all zeros in the readout.

b. Carefully continue the adjustment in the same direction until a "1" just appears in the right-most decade. Note the position of the slot in the potentiometer shaft.

c. Carefully back off the adjustment through the zero reading until again a "1" appears in the right-most decade. Note the position of the slot in the potentiometer shaft.

d. For a true zero, set the potentiometer halfway between the two positions noted.

2-24. OVERLOAD INDICATION AND DOWN-RANGING.

2-25. Anytime the input to the instrument exceeds the full scale value of the range in which it is operating, an overload indication appears in the readout as a numeral "1" in the left-most decade with the remaining decades blank; appropriate polarity, if any, and a decimal will be displayed.

2-26. To remove the overload indication, up-range the instrument until the indication disappears. In the measurement of voltage, current, resistance or capacitance, it may also be necessary to change functions.

Example: With the instrument operating in the mV (DC) function, left decimal illuminated and a +6.35V input, an overload indication will be displayed. Pressing the mid decimal or right decimal switches will not remove the overload indication. In this case, it will be necessary to press the V (DC) function switch. However, since the instrument automatically selects the highest range of any function actuated, the right decimal will be illuminated as the meter

is in the 1000V range and the readout will display +006. - not the correct reading. Pressing the mid decimal switch will cause the meter to display +06.3 - still not the correct reading. Pressing the left decimal switch will place the instrument in the correct range and the display will be +6.35.

2-27. OPERATION.

2-28. INITIAL TURN-ON.

a. If operating the TT-20B from batteries, ensure that they are properly charged. If operating either model from line power, ensure charger unit is plugged into instrument and into correct line power source.

b. Upon pressing the PWR ON switch, the instrument will automatically select the V (DC) function in the 1000V range (right decimal illuminated).

c. Any subsequent function selection will always place the instrument in the highest range programmed for that function. Also the meter is programmed to ignore any range selection not applicable to any particular function.

Examples: In selecting the °F function, the decimal will be in the right-most position (000.) and cannot be moved. In selecting the MΩ function, the decimal will be in the left-most position (0.00) and cannot be moved.

2-29. DC VOLTS MEASUREMENT.

a. Plug input leads into instrument; red into INPUT jack and black into COMMON jack.

b. Press PWR ON switch. Instrument will automatically select V (DC) function in the 1000V range (right decimal).

c. Apply probe of black lead to voltage common and probe of red lead to voltage source.

d. If reading is less than 200, down-range until maximum resolution is obtained for a correct reading.

2-30. DC MILLIVOLTS MEASUREMENT.

a. Connect input leads as set forth in paragraph 2-29, step a and short the two probes together.

b. Press PWR ON switch then mV (DC) switch and then left decimal switch.

c. Zero readout (0.00) by adjusting mV offset potentiometer on rear panel. Refer to paragraph 2-22 for procedure to obtain a true zero.

d. Apply probe of black lead to voltage common and probe of red lead to voltage source.

e. If reading is less than 200, down-range until maximum resolution is obtained for correct reading.

2-31. AC VOLTS MEASUREMENT. Perform steps set forth in DC volts measurement (paragraph 2-29), except press V (AC) switch after PWR ON switch is actuated.

2-32. AC MILLIVOLTS MEASUREMENT. Perform steps set forth in DC millivolts measurement (paragraph 2-30), except offset adjustment is not required. Press mV (AC) switch after PWR ON switch is actuated.

2-33. CURRENT MEASUREMENT.

a. Plug input leads into instrument, red into CURRENT jack and black into COMMON jack.

b. Press PWR ON switch then appropriate current function switch, either A (DC), mA (DC), μA (DC), A (AC) or mA (AC).

c. Apply probe of black lead to current common and probe of red lead to current source.

d. If measurement is in amperes, reading is correct. If measurement is in milliamperes or microamperes and reading is less than 200, down-range until maximum resolution is obtained for correct reading.

2-34. RESISTANCE MEASUREMENT.

a. Perform steps a thru c under paragraph 2-30.

b. If kilohm measurements are to be made, offset adjustment in kΩ function is required. If ohms measurements are to be made, offset adjustments are required in both kilohms and ohms functions.

c. Ensure that power is ON and INPUT and COMMON jacks shorted.

d. For kilohm measurement, zero readout (00.0) by presssing kΩ switch then mid decimal switch and adjusting kΩ offset potentiometer on rear panel. Refer to paragraph 2-22 for procedure to obtain a true zero.

e. For ohms measurement, perform step d above and then zero readout (0.00) by pressing Ω switch then left decimal switch and adjusting Ω offset potentiometer on rear panel. Reference is again made to paragraph 2-22.

f. Connect resistance to be measured to INPUT and COMMON jacks.

g. Press appropriate resistance function switch, either MΩ, kΩ or Ω.

h. If measurement is in megohms, reading is correct. If measurement is in kilohms or ohms and reading is less than 200, down-range until maximum resolution is obtained for correct reading.

2-35. CONTINUITY MEASUREMENT.

a. Perform steps a thru e under paragraph 2-34.

b. Press switch.

c. Connect resistance to be measured to INPUT and COMMON jacks. Listen to the pitch of tone generator for a quick indication of the reading: Low note - short circuit, High note - near full scale, Quiet - overload.

d. For accurate measurement look at the reading in the display.

2-36. DIODE TEST.

a. Perform steps a thru c under paragraph 2-30.

b. Connect leads of diode to INPUT and COMMON jacks (cathode to COMMON).

c. Press diode switch.

d. Readout will display in millivolts the forward breakdown voltage of the diode junction at 100 μA.

e. Reverse diode leads; a good diode will display an overload condition.

f. Press nS switch.

g. If reading is less than 200, down-range for correct reading.

h. Reading will display conductance in nanosiemens. This number must be divided into 1000 to obtain a value in megohms. This number may also be multiplied by 10 to obtain the leakage current in nanoamperes with 10V reverse bias. Thus the mid decimal nS range indicates from 001 nA to 1999 nA. The left decimal range indicates from 00.1 nA to 199.9 nA.

2-37. CONDUCTANCE MEASUREMENT.

a. Perform steps a thru c under paragraph 2-30.

b. With PWR ON, press nS switch then left decimal switch.

c. With the INPUT and COMMON jacks open (no connections), zero readout (0.00) by adjusting nS offset potentiometer on rear panel. Refer to paragraph 2-22 for procedure to obtain a true zero.

d. Press nS switch again and connect conductance to be measured to INPUT and COMMON jacks.

e. If reading is less than 200, down-range for correct reading.

2-38. The following data is provided to clarify the relationship between conductance and resistance and to aid in converting nanosiemen values into megohms.

2-39. Resistance is the reciprocal of conductance:

$$R = \frac{1}{S}$$

R = Resistance in ohms
S = Conductance in siemens

2-40. For megohms of insulation resistance:

$$R = \frac{10^3}{nS}$$

R = Resistance in megohms
nS = Nanosiemens

2-41. Using the last formula, readings from the TT-20 can be converted directly to insulation resistance readings. The following are some generalized examples:

Nanosiemens	Megohms	Condition of Insulation
00.01	100,000	Excellent
00.02	50,000	Very good
00.05	20,000	Good
00.10	10,000	Fair
00.20	5,000	Not very good
00.50	2,000	Poor
01.00	1,000	Very poor
02.00	500	
05.00	200	
10.00	100	
20.00	50	

2-42. At one nanosiemen, insulation resistance is only 1000 megohms. This will cause an error of 1% or 100,000 ohms across a 10 megohm resistor. In high resistance circuits (worst case design), 1000 megohms would be totally unacceptable. However if no high resistor values are involved then even lower insulation resistance would be tolerable.

2-43. CAPACITANCE MEASUREMENT.

a. Perform steps a thru c under paragraph 2-30.

b. If picofarads are to be measured, a pF offset adjustment is required.

c. With INPUT and COMMON jacks open (no connections), press PWR ON switch then pF switch.

d. Zero readout (000.) by adjusting pF offset potentiometer on rear panel.

e. Connect capacitance to be measured to INPUT and COMMON jacks.

f. Press appropriate capacitance function switch, either μF, nF or pF.

g. If measurement is in pF, reading is correct. If measurement is in nF and reading is less than 200, down-range until maximum resolution is obtained for correct reading. If measurement is in μF and reading is less than 20, down-range for correct reading.

2-44. TEMPERATURE MEASUREMENT.

a. Connect temperature probe to INPUT and COMMON jacks. The raised side of plug goes to COMMON.

b. Press PWR ON switch.

c. Apply probe to temperature source.

d. Press °F switch; reading will display probe temperature in degrees Fahrenheit.

e. Press °C switch; reading will display probe temperature in degrees Celsius.

NOTE

For full accuracy (steps d and e above), allow enough time for readings to stabilize.

SECTION III

THEORY OF OPERATION

3-1. INTRODUCTION.

3-2. The model TT-20 is a digital multimeter with many unusual features. It is capable of operating from the AC line or internal rechargeable batteries. Front-panel pressure-sensitive switches allow touch selection of the TT-20's functions, ranges and on-off power. Function and range switching is accomplished via microprocessor-controlled logic circuits that connect the proper signal conditioning circuits to the A/D converter.

3-3. This section provides a brief description of the various circuits within the instrument which enable it to perform its many measuring functions. In addition to circuit descriptions, simplified schematic and block diagrams are provided. Complete schematic diagrams are located at the rear of this manual.

3-4. The model TT-20 is of modular construction using plug-in printed circuit boards for ease of assembly and servicing. These boards may be described as follows:

1. Display Board. This module contains the basic A/D circuits, an active filter and readout assembly.

2. Signal Conditioning Board No. 1. This module contains the input attenuator, the AC to DC conversion circuits and a preamplifier.

3. Signal Conditioning Board No. 2. This module contains the circuits that process resistance and capacitance measurements, producing an output compatible with the A/D input.

4. Signal Conditioning Board No. 3. This module contains the circuits that process temperature and conductance measurements. A tone generator is also located on this board.

5. Power Supply Board. This module contains the rectifiers, a battery charging circuit, a DC/DC converter and the regulated supplies.

6. Front Panel Assembly. This assembly contains the input terminals the membrane switches, which control instrument operation, and switch illuminating LED's.

7. Main Board Assembly. The main board assembly provides the basic structure for the instrument, board interconnections, the microprocessor, and most of the logic circuits.

3-5. DISPLAY BOARD.

3-6. The display board contains the A/D converter and its readout display. All measurements are processed and converted to digital form by the A/D converter. The output of the A/D converter operates the readout display.

3-7. Figure 3-1 shows the basic block diagram of the display board. Signals applied to input terminal 4 feed an active filter composed of R21 & AR1 and its associated components. This filter provides a 60 db attenuation at 60 Hz. The filtered input is applied to pin 31 of the A/D converter, U1.

3-8. An external reference is used to provide improved DVM stability and faster warm up. Polarity enable and decimal logic circuits are also located on this board.

3-9. SIGNAL CONDITIONING BOARD NO. 1.

3-10. Signal Conditioning Board No. 1 contains the attenuator with its associated electromechanical and solid-state relays, the AC-to-DC conversion circuits, and AC and DC preamplifiers. The attenuator is used for VDC, VAC, mVDC, and mVAC only.

3-11. Front-panel pressure-switches select the multimeter functions by actuating logic circuits which drive the proper relays, setting the attenuator. On AC functions, the logic inserts the AC-to-DC converter.

3-12. The parameters which determine the measurement range

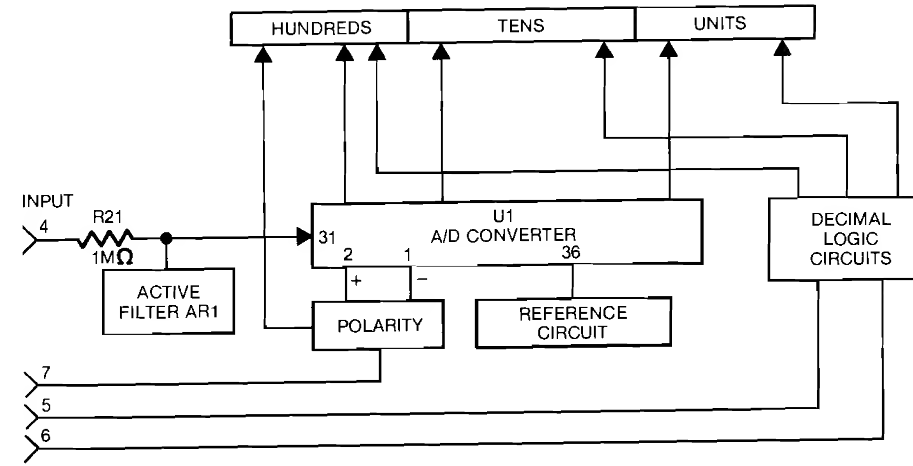

Figure 3-1. Simplified Block Diagram - Display Board

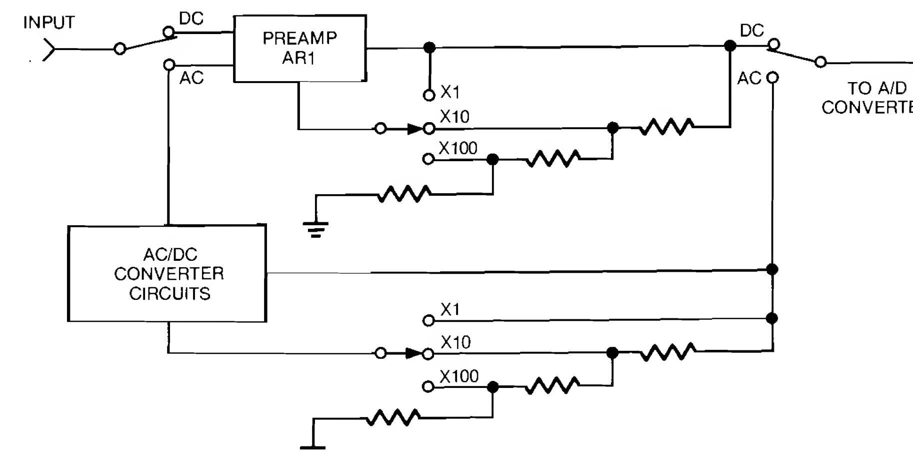

Figure 3-2. Simplified Schematic Diagram - Attenuator, AC/DC Converter and Preamplifier Switching

vary with the type of measurement. For example, in current measurements, the significant parameters are the shunt resistance and the preamplifier gain. For voltage measurement it is the attenuator tap and the preamplifier gain, etc. Table 3-1 lists the significant range-determining parameters for all the functions.

3-13. Figure 3-2 illustrates in simplified block diagram form the basic function of Signal Conditioning Board No. 1.

3-14. <u>SIGNAL CONDITIONING BOARD NO. 2</u>.

3-15. Signal Conditioning Board No. 2 contains the circuits which provide the DVM with resistance, diode test and capacitance measurement capability. When measuring resistance or capacitance, these circuits provide a DC voltage level proportional to the measured component value.

3-16. RESISTANCE.

3-17. Resistance measurements are made by passing an accurate constant-current through the unknown resistance and measuring the resultant voltage drop. Figure 3-3 provides a simplified schematic of the resistance memory circuit. VR1 and AR2 form a constant-current source. Feedback resistor Ra determines the current. Resistors Rb, Rc and Rd are switched into the feedback loop by the range selection front-panel switch, the associated logic circuits and solid-state relays (SSR). Thus the constant-current supply may be switched through several values of current for the various resistance ranges. The voltage drop across the unknown resistor is buffered by AR1 and conducted through a solid-state relay to the A/D converter. Thermistor T1 acts to protect the circuitry from inadvertant application of external power and its presence is compensated for in the circuitry.

3-18. DIODE TEST.

3-19. Diode testing utilizes the same test configuration as is used in resistance measurements (figure 3-3). In the diode test mode, the constant-current source VR1 and AR2 provides a one milliamp current through the diode under test. The resultant voltage drop is buffered by AR1 and conducted through the solid-state switch to the A/D conver-

Table 3-1. Range-Determining Parameters (Sheet 1 of 2)

FUNCTION	RANGE-DETERMINING PARAMETERS	RANGE 19.99	199.9	1999.
A (DC)	Shunt Resistance	.01Ω	-	-
	DC Preamp Gain	10	-	-
mA (DC)	Shunt Resistance	10Ω	.1Ω	.1Ω
	DC Preamp Gain	10	100	10
µA (DC)	Shunt Resistance	1 kΩ	1 kΩ	10Ω
	DC Preamp Gain	100	10	100
A (AC)	Shunt Resistance	.01Ω	-	-
	AC Preamp Gain	10	-	-
mA (AC)	Shunt Resistance	10Ω	.1Ω	.1Ω
	AC Preamp Gain	10	100	10
V (DC)	Attenuator Tap	1000/1	1000/1	1000/1
	DC Preamp Gain	100	10	1
mV (DC)	Attenuator Tap	1/1	1/1	1/1
	DC Preamp Gain	100	10	1
V (AC)	Attenuator Tap	1000/1	1000/1	1000/1
	AC Preamp Gain	100	10	1
mV (AC)	Attenuator Tap	1/1	1/1	1/1
	AC Preamp Gain	100	10	.1
MΩ	Test Current	.1 µA	-	-
	DC Preamp Gain	1	-	-

Table 3-1. Range-Determining Parameters (Sheet 2 of 2)

FUNCTION	RANGE-DETERMINING PARAMETERS	RANGE 19.99	199.9	1999.
kΩ	Test Current	10 µA	.1 µA	.1 µA
	DC Preamp Gain	10	100	10
Ω	Test Current	1 mA	1 mA	10 µA
	DC Preamp Gain	100	10	100
(continuity)	Test Current	1 mA	1 mA	10 µA
	DC Preamp Gain	100	10	100
°F	Sensor Bias Current	-	-	100 µA
	DC Preamp Gain	-	-	1
°C	Sensor Bias Current	-	-	100 µA
	DC Preamp Gain	-	-	1
µF	Charging Current	1 mA	1 mA	-
	DC Preamp Gain	10	1	-
nF	Charging Current	.1 µA	10 µA	10 µA
	DC Preamp Gain	1	10	1
pF	Charging Current	-	-	.1 µA
	DC Preamp Gain	-	-	10
(diode)	Test Current	-	-	1 mA
	DC Preamp Gain	-	-	1
nS	Test Voltage	10V	10V	-
	DC Preamp Gain	10	1	-

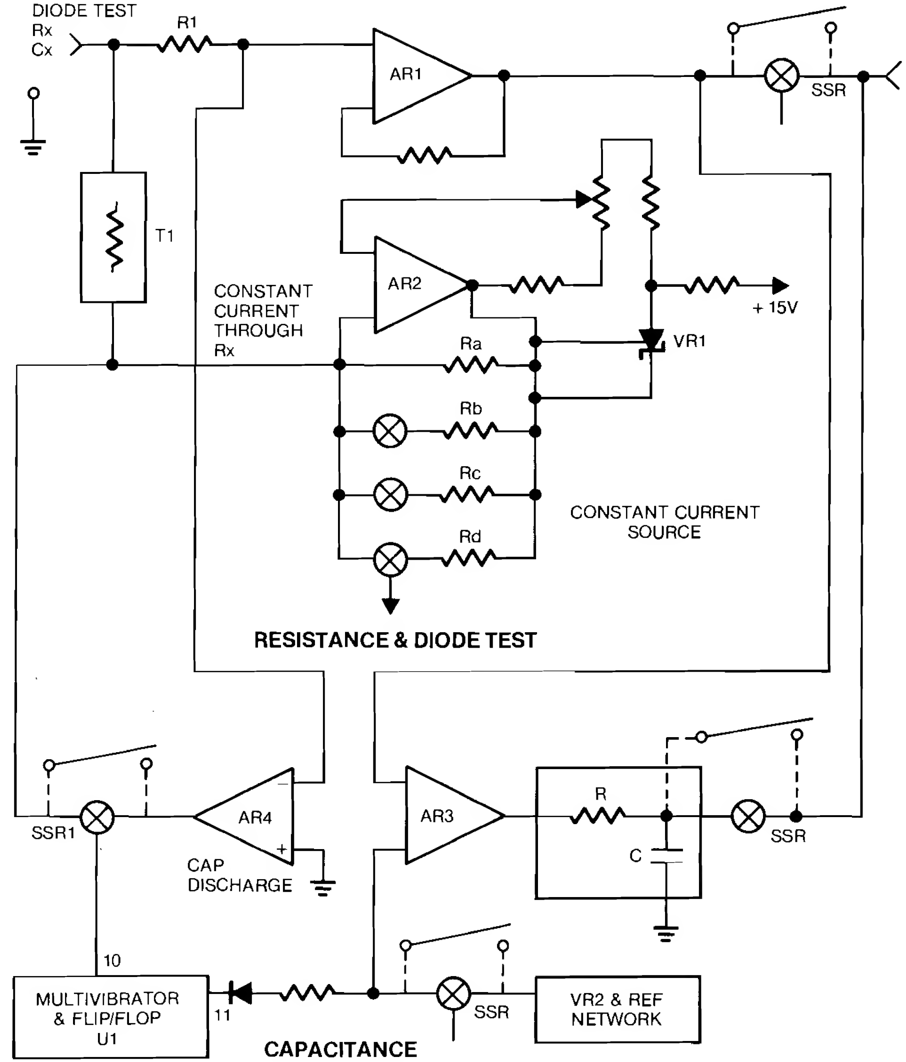

Figure 3-3. Simplified Schematic Diagram - Resistance and Capacitance

ter. The meter displays the forward voltage drop in millivolts, and overload when the diode is reversed.

3-20. CAPACITANCE.

3-21. Capacitance measurements are made by determining the time it takes for the unknown capacitor to charge from one fixed voltage to another, using a constant-charging current. This time, which is directly proportional to the capacitance, is then converted to voltage which is, in turn, delivered to the A/D converter.

3-22. The constant-current source, VR1 and AR2, used for resistance measurements, is also used to charge the unknown capacitor.

3-23. The capacitance measuring circuit operates as follows (See figure 3-3). Unknown capacitor Cx is charged by constant-current source VR1 and AR2. The voltage across Cx is applied to buffer AR1 and is fed to AR3. AR3 acts as a comparator, comparing the voltage from the unknown capacitor to a reference voltage at its other input. When the voltage from the capacitor reaches the reference voltage, the output of AR3 goes low, and remains low until a new charging cycle starts under control of multivibrator U1. The value of the unknown capacitance is proportional to the average value of the output of AR3. This output is filtered and delivered to the A/D converter.

3-24. Capacitor ranges are selected by front-panel switches which act through logic circuits to switch the constant-current supply ranges, as is done in resistance measurements.

3-25. SIGNAL CONDITIONING BOARD NO. 3.

3-26. Signal Conditioning Board No. 3 contains the circuits which provide the DVM with temperature and conductance measurement capability. An audible continuity check circuit is also incorporated on this board.

3-27. TEMPERATURE.

3-28. When the model TT-20 is switched to the temperature mode, logic circuits activate the necessary solid-state and electromechanical relays, connecting a 100 microamp con-

stant-current source (from Signal Conditioning Board No. 2) to the transistor temperature probe. Figure 3-4 outlines the basic temperature measuring circuit. Since the voltage across the transistor probe varies with temperature, a voltage change proportional to probe temperature is generated. Amplifier AR4 is driven by the voltage through resistors R1 and R2. Amplifier gain is set by the ratio of feedback resistor R3 to R1 and R2. Degrees Fahrenheit or Celsius may be selected, the logic switching R1 in or out of the circuit, adjusting circuit offset gain to compensate for Fahrenheit or Celsius readings.

3-29. AUDIBLE CONTINUITY CHECK.

3-30. The audible continuity check circuit is an adjunct to the three lower ohms ranges of the multimeter, providing a convenient audible check for quick testing. When in the three lower ranges, this circuit may be enabled by pressing the front-panel switch. Logic circuits connect the continuity circuit input to the A/D converter output and permits the voltage-controlled oscillator (VCO) to operate.

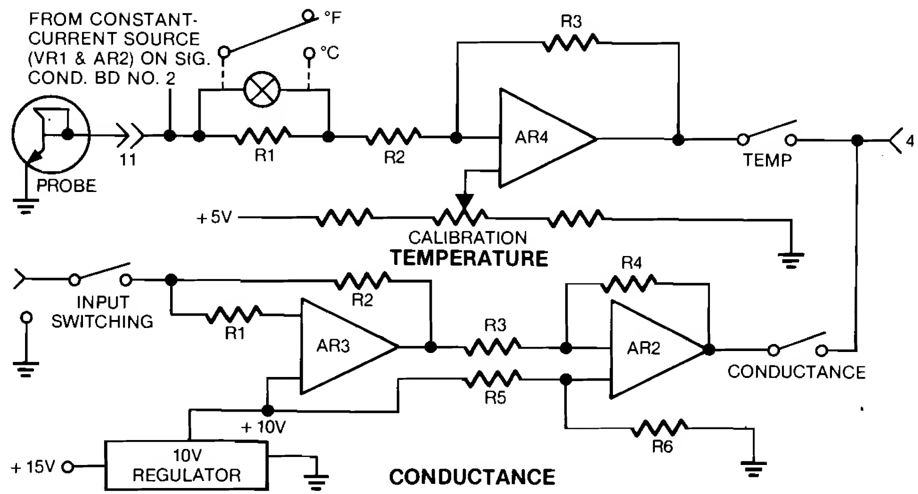

Figure 3-4. Simplified Schematic Diagram - Temperature and Conductance

3-31. The circuit consists of a VCO, AR5 and AR6 (figure 3-5), which drives a transducer thru U2. AR1 and its associated resistors form a control circuit for the oscillator. When switching meter functions or ranges, a control signal appears at terminal 17, turns on solid-state relay 2 (SSR2) so that a voltage divider formed by R28 and R29 supplies a voltage to R21 and R30. AR1 is turned on and a 1 kHz beep is emitted, indicating a change in meter operation.

3-32. In the normal continuity mode, a voltage from the A/D converter preamplifier output is present at terminal 16. Logic signals at terminals 6 and 17 turn on SSR1 and shut off SSR2, applying the signal voltage to AR1 through R30 which enables the VCO to operate. At the same time the signal is also applied through R21 to the oscillator, adjusting its pitch. Oscillator pitch will vary from approximately 500 Hz for minimum resistance readings to 2.5 kHz for maximum full scale readings. Above full scale, the tone shuts off.

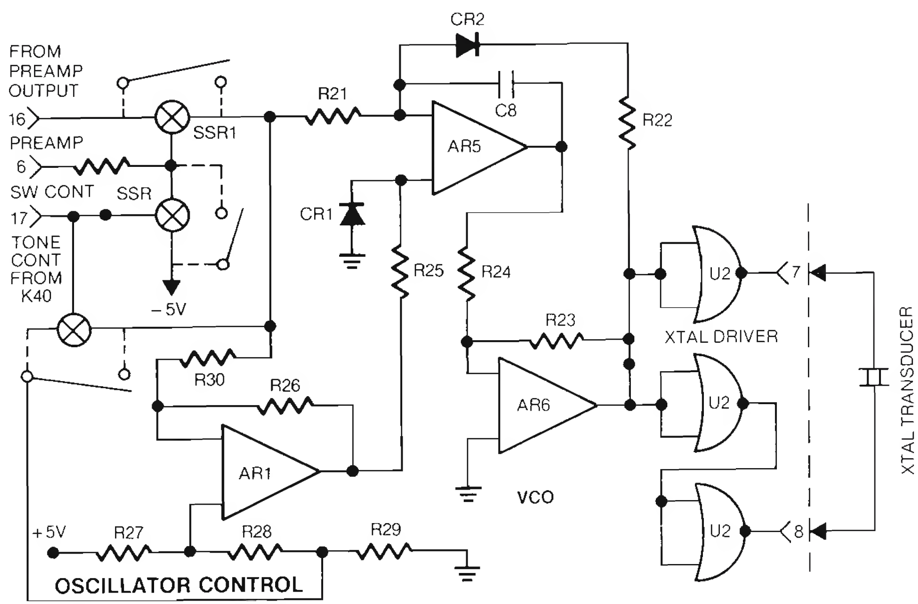

Figure 3-5. Simplified Schematic Diagram - Continuity

3-33. CONDUCTANCE.

3-34. Conductance is measured in nanosiemens. One nanosiemen is equal to 1,000 megohms. A siemen is the reciprocal of an ohm, i.e. 1 siemen = 1/ohm and 1 nanosiemen = 10 to the minus 9th siemen or 1,000 megohms.

3-35. Pressing the nS front-panel switch engages the logic circuits which activate the relays connecting the conductance circuit to the input of the DVM.

3-36. The basic conductance circuit is comprised of operational amplifiers AR2, AR3 and a +10V regulator (figure 3-4). One input of AR3 is held at +10V, while its output is fed back to its second input through R1 and R2. Operational amplifier AR2 operates as a differential amplifier, receiving a balanced DC input from the +10V regulator through R5 and from the output of AR3 via R3. Any leakage to ground at the junction of R1-R2 in the feedback loop around AR3 unbalances the input to AR2. The resulting output is a voltage proportional to the leakage in nanosiemens or kilomegohms.

3-37. POWER SUPPLY BOARD.

3-38. The power supply board contains a bridge rectifier, a battery charging circuit, a +5V regulator and a DC-to-DC converter. External AC power is received from a wall-plug transformer.

3-39. Figure 3-6 shows a simplified block diagram of the power supply module. The external transformer supplies AC power to the bridge rectifier. The output of the rectifier is regulated to 7.5 volts to charge the instrument batteries which are capable of operating the instrument for approximately six hours. The battery voltage is then regulated to +5V, permitting the instrument to operate reliably over wide variations of battery voltage. The 5V regulator also supplies the DC-to-DC converter which generates a +15V and a -5V source for other instrument circuits.

3-40. The front-panel power on-off switches operate a logic circuit flip-flop which provides an on-off state to the +5V regulator (pins 15 and 17). Since the "off" mode is maintained by a CMOS flip-flop, only a negligible battery current is required in this state. The transducer for the

audible continuity check circuit is also located on this module.

3-41. MAIN BOARD ASSEMBLY.

3-42. The main board assembly provides the basic structure of the multimeter, the module interconnections, the current measuring circuits, and contains most of the instrument logic circuitry. Central to the instrument logic is a microprocessor, used to control all function and range switching. The microprocessor monitors the front-panel switches, sensing which function and range switch has been activated. It then provides for the lighting of the appropriate panel indicator, a beep tone when a switch is depressed and the switching of all electromechanical and solid-state relays necessary to attain the function and range selected. See figure 3-7.

3-43. Insight into the action of the instrument logic will be clarified by a review of tables 3-2 through 3-4 and the main board schematic diagram located at the rear of this manual. Using these tables and the main board schematic, a

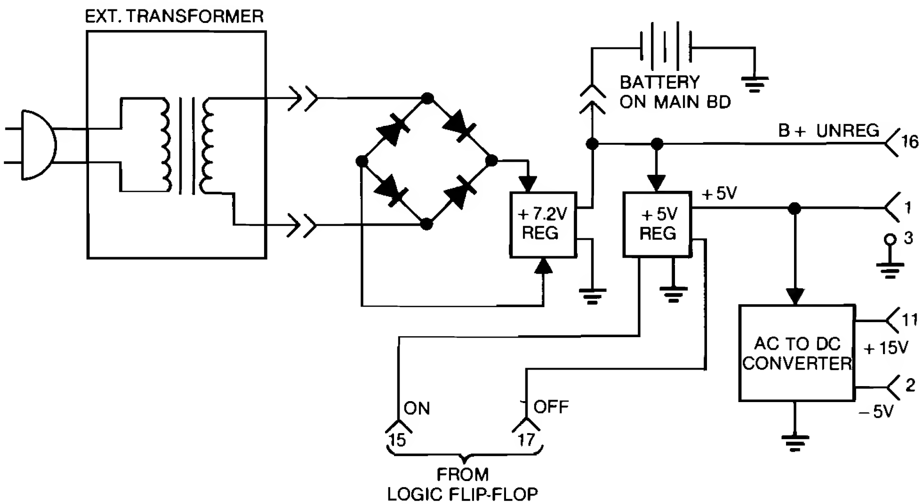

Figure 3-6. Simplified Diagram - Power Supply

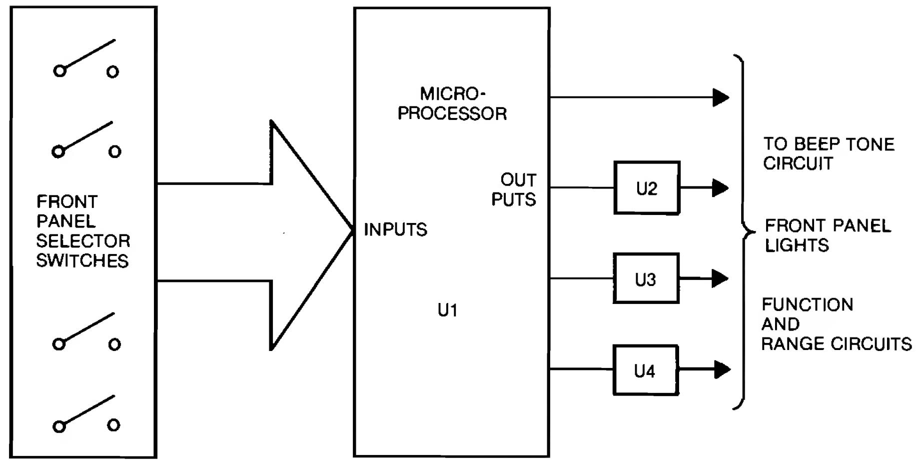

Figure 3-7. Simplified Block Diagram - Microprocessor Logic Circuits

signal from the microprocessor U1 or ICs U2 or U3 may be traced to the driven relay or circuit.

3-44. Table 3-2 shows which relays are actuated by the logic in any of the 20 functions when in the low range. Tables 3-3 and 3-4 simularly indicate conditions in the mid and high ranges, respectively.

Table 3-2. Function/Logic Signal Relationship - 19.99 Range

LOGIC IC #	SIGNAL PIN #	DRIVEN RELAY OR CIRCUIT	ADC	mADC	µADC	AAC	mAAC	VDC	mVDC	D.T.	VAC	mVAC	nS	MΩ	kΩ	Ω	CONT	°F	°C	µF	nF	pF
U3	12	DECIMAL HI																				
U3	11	DECIMAL LO																				
U1	22	K1											X	X	X	X	X			X	X	
U1	21	K2									X	X	X									
U1	19	K3		X	X		X															
U1	18	K4			X																	
U1	37	K5	X	X	X	X	X	X	X		X	X										
U2	5	K10														X	X			X		
U2	5	K11														X	X			X		
U1	30	K12													X							
U2	11	K14																				
U2	11	K34																				
U1	31	K15												X	X	X	X					
U2	3	K18							X			X										
U1	36	K19						X	X		X	X										
U1	35	K23				X	X				X	X										
U1	33	K24	X	X		X	X						X		X					X		
U1	34	K25			X			X	X		X	X				X	X					
U1	32	K31																		X	X	
U2	12	K33																				
U2	10	K35											X									
U2	6	K36															X					
U3	3	POLARITY	X	X	X			X	X													
U1	39	K40	BEEPER OPERATION																			

NOTES:
1. X indicates HI logic level.
2. K40 logic level goes HI whenever range or function switch is actuated.
3. Left decimal point line goes HI on this range.
4. This is a forbidden range for the °F, °C, pF and diode test functions; if it is selected by the user, meter will ignore the command and select and display the 1999. range.
5. In the TT-21 & TT-21B, relays K1 & K3 are replaced by a single relay, K1, and relays K2 & K4 are replaced by K2.

Table 3-3. Function/Logic Signal Relationship - 199.9 Range

LOGIC IC #	SIGNAL PIN #	DRIVEN RELAY OR CIRCUIT	ADC	mADC	µADC	AAC	mAAC	VDC	mVDC	D.T.	VAC	mVAC	nS	MΩ	kΩ	Ω	CONT	°F	°C	µF	nF	pF
U3	12	DECIMAL HI																				
U3	11	DECIMAL LO																				
U1	22	K1											X		X	X	X			X	X	
U1	21	K2									X	X	X									
U1	19	K3			X																	
U1	18	K4		X	X		X															
U1	37	K5		X	X		X	X	X		X	X										
U2	5	K10														X	X			X		
U2	5	K11														X	X			X		
U1	30	K12																			X	
U2	11	K14																				
U2	11	K34																				
U1	31	K15													X	X	X					
U2	3	K18							X			X										
U1	36	K19						X	X		X	X										
U1	35	K23					X				X	X										
U1	33	K24			X			X	X		X	X				X	X				X	
U1	34	K25		X			X								X							
U1	32	K31																		X	X	
U2	12	K33																				
U2	10	K35											X									
U2	6	K36															X					
U3	3	POLARITY		X	X			X	X													
U1	39	K40	BEEPER OPERATION																			

NOTES:
1. X indicates HI logic level.
2. K40 logic level goes HI whenever range or function switch is actuated.
3. This is a forbidden range for the AAC, ADC and MΩ functions; if it is selected by the user, meter will ignore the command and select and display the 19.99 range.
4. This is also a forbidden range for the °F, °C, pF and diode test functions; if it is selected by the user, meter will ignore the command and select and display the 1999. range.
5. In the TT-21 & TT-21B, relays K1 & K3 are replaced by a single relay, K1, and relays K2 & K4 are replaced by K2.

Table 3-4. Function/Logic Signal Relationship - 1999. Range

LOGIC IC #	SIGNAL PIN #	DRIVEN RELAY OR CIRCUIT	ADC	mADC	µADC	AAC	mAAC	VDC	mVDC	D.T.	VAC	mVAC	nS	MΩ	kΩ	Ω	CONT	°F	°C	µF	nF	pF
U3	12	DECIMAL HI																				
U3	11	DECIMAL LO																				
U1	22	K1								X					X	X	X	X	X		X	X
U1	21	K2									X	X										
U1	19	K3			X																	
U1	18	K4		X			X															
U1	37	K5		X	X		X	X	X		X	X										
U2	5	K10								X												
U2	5	K11								X												
U1	30	K12														X	X				X	
U2	11	K14																X	X			
U2	11	K34																X	X			
U1	31	K15								X					X	X	X					
U2	3	K18							X			X										
U1	36	K19						X	X		X	X										
U1	35	K23					X				X	X										
U1	33	K24		X			X								X							X
U1	34	K25			X											X	X					
U1	32	K31																			X	X
U2	12	K33																X				
U2	10	K35																				
U2	6	K36															X					
U3	3	POLARITY		X	X			X	X	X								X	X			
U1	39	K40	BEEPER OPERATION																			

NOTES: 1. X indicates HI logic level.

2. K40 logic level goes HI whenever range or function switch is actuated.

3. Right decimal point line goes HI on this range.

4. This is a forbidden range for the AAC, ADC and MΩ functions; if it is selected by the user, meter will ignore the command and select and display the 19.99 range.

5. This is also a forbidden range for the µF and nS functions; if it is selected by the user, meter will ignore the command and select and display the 199.9 range.

6. In the TT-21 & TT-21B, relays K1 & K3 are replaced by a single relay, K1, and relays K2 & K4 are replaced by K2.

SECTION IV

CALIBRATION

4-1. INTRODUCTION.

4-2. In the calibration instructions provided in this section, it is assumed that the instrument is in good working order and only requires calibration. If any components are defective, it may be difficult, if not impossible to calibrate the instrument. Figure 4-1 displays the location of components required for adjustment.

4-3. EQUIPMENT REQUIRED.

a. DC Voltage Standard, John Fluke Model 332A, or equivalent.

b. AC Voltage Standard, Holt Model 631B, or equivalent.

c. Resistance Standard, E.S.I. Model DB52, or equivalent.

d. Capacitance Standard or a capacitor of known value, approximately 1800 picofarads.

e. Digital Multimeter, NLS Model TT-20, or equivalent.

f. Variable Output DC Power Supply, Power Design Model 20015R, or equivalent.

4-4. INITIAL PREPARATION.

a. Remove screw from bottom of case.

b. Gently slide instrument chassis out of case.

NOTE

These procedures must be performed in the following order since early adjustments will have an effect upon those performed later on.

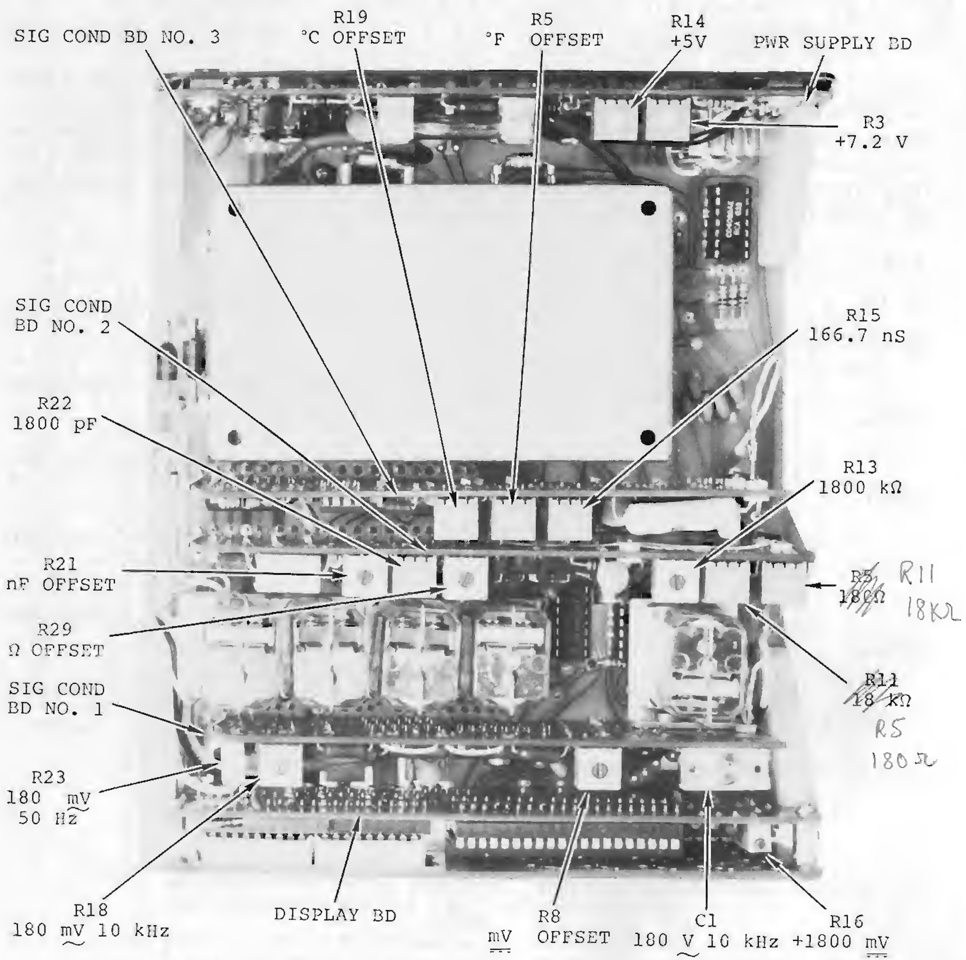

Figure 4-1. Calibration Adjustments

4-5. PROCEDURE.

4-6. CHARGING CIRCUIT (TT-20B).

a. Remove the 2A fuse from its fuse clips on the rear board. Attach a 1000 μF/10V capacitor and a 1 kΩ resistor in parallel from the right-hand fuse clip, as you face the instrument, to ground. The negative terminal of the capacitor connects to ground.

b. Insert the plug of the transformer (charger unit) cord into the instrument and plug the transformer into the appropriate power source.

c. Adjust R3 on Power Supply Board (figure 4-1) so that voltage across capacitor measures +7.2 VDC ±0.05 VDC.

d. Unplug charger, disconnect the resistor and capacitor and replace fuse.

4-7. CHARGING CIRCUIT (TT-20)

a. Insert plug of transformer (charger unit) cord into instrument and plug transformer into appropriate power source.

b. Press PWR ON switch.

c. Adjust R3 on Power Supply Board (figure 4-1) so that voltage at the 2A fuse measures +7.2 VDC ±0.05 VDC with respect to ground.

4-8. +5 VDC REGULATOR AND BATTERY DISCHARGE CUTOFF (TT-20B).

a. Unplug charger, remove fuse on rear board and connect +6.3 VDC from a DC power supply to the instrument (+ to right-hand fuse clip, as you face the instrument, - to ground).

b. Press PWR ON switch and observe that the instrument is on.

c. Adjust R14 on Power Supply Board (figure 4-1) so that voltage at pin 1 of any plug-in board measures +5.00 VDC ±0.05 VDC with respect to ground (pin 3).

d. Decrease the +6.3 VDC gradually to +5V. At about +5.2V the instrument will turn off. This protects the batteries from deep discharge.

e. Disconnect DC power supply and replace fuse.

4-9. +5 VDC REGULATOR (TT-20).

a. Plug transformer (charger unit) into instrument and an appropriate power source of line voltage.

b. Press PWR ON switch.

c. Adjust R14 on Power Supply Board (figure 4-1) so that voltage at pin 1 of any plug-in board measures +5.00 VDC ±0.05 VDC with respect to ground (pin 3).

NOTE

The remainder of these calibration procedures apply equally to the TT-20 and TT-20B instruments. If your instrument is a TT-20B, be certain that the batteries are charged.

4-10. PREAMPLIFIER OFFSET.

a. Press PWR ON switch.

b. Short INPUT jack to COMMON jack.

c. Press mV (DC) switch and then left decimal switch.

d. Set mV OFFSET potentiometer on rear panel to the center of its travel.

e. Adjust R8 on Signal Conditioning Board No. 1 (figure 4-1) so that readout displays + or - 0.00.

f. Remove short from input jacks.

4-11. A/D CONVERTER REFERENCE.

a. Connect INPUT and COMMON jacks to output of the DC voltage standard, using input leads provided with instrument.

b. Press PWR ON switch and then mV (DC) switch.

c. Set voltage standard to +1.800 VDC.

d. Adjust R16 on display board (figure 4-1) so that readout displays +1800.

e. Disconnect TT-20 from voltage standard.

4-12. AC/DC CONVERTER SCALE FACTOR.

a. Using the input leads supplied with instrument, connect the INPUT and COMMON jacks to the output of the AC voltage standard.

b. Press PWR ON switch.

c. Press mV (AC) switch and then mid decimal switch.

d. Set the standard to .1800 volts at 50 Hz.

e. Adjust R23 on Signal Conditioning Board No. 1 (figure 4-1) so that readout displays 180.0.

f. Set the standard to 10 kHz.

g. Adjust R18 on Signal Conditioning Board No.1 (figure 4-1) so that readout displays 180.0.

4-13. 1000:1 ATTENUATOR HIGH FREQUENCY.

a. Press V (AC) switch and then mid range switch.

b. Set the AC standard to 180.0 volts at 10 kHz.

c. Adjust C1 on Signal Conditioning Board No. 1 (figure 4-1) so that readout displays 180.0.

4-14. RESISTANCE-TO-DC CONVERTER OFFSET.

a. Using the input leads supplied with instrument, short the INPUT to COMMON.

NOTE

If resistance measurements are to be made using different leads or the component adapter, steps a, f and g of these procedures must be repeated for this different input condition.

b. Press PWR ON switch.

c. Press kΩ switch and then mid decimal switch.

d. Set kΩ offset potentiometer on rear panel to the middle of its travel.

e. Adjust R29 on Signal Conditioning Board No. 2 (figure 4-1) so that readout displays 00.0.

f. Press Ω switch then left decimal switch.

g. Adjust Ω offset potentiometer on rear panel so that readout displays 0.00.

4-15. RESISTANCE-TO-DC CONVERTER SCALE FACTOR.

a. Using the input leads supplied with instrument, connect INPUT and COMMON jacks to the resistance standard.

b. Press PWR ON switch.

c. Press Ω switch and then mid decimal switch.

d. Set the standard to 180.0Ω.

e. Adjust R5 on Signal Conditioning Board No. 2 (figure 4-1) so that readout displays 180.0.

f. Set the standard to 18.00 kΩ.

g. Press kΩ switch and then left decimal switch.

h. Adjust R11 on Signal Conditioning Board No. 2 (figure 4-1) so that readout displays 18.00.

i. Set the standard to 1.800 MΩ.

j. Press kΩ switch again or the right decimal switch.

k. Adjust R13 on Signal Conditioning Board No. 2 (figure 4-1) so that readout displays 1800.

4-16. CAPACITANCE-TO-DC CONVERTER OFFSET.

a. Plug component adapter into INPUT and COMMON jacks.

b. Press PWR ON switch.

c. Press nF switch and then mid decimal switch.

d. Set pF offset potentiometer on rear panel to the middle of its travel.

e. Adjust R21 on Signal Conditioning Board No. 2 (figure 4-1) so that readout displays 00.0.

f. Press pF switch and adjust pF offset potentiometer on rear panel so that readout displays 000.

NOTE

There is some instability in the readings in capacitance measurements, even at zero. This is caused by line frequency pick-up and can be minimized by shielding the input adapter and the component under test.

4-17. CAPACITANCE-TO-DC CONVERTER SCALE FACTOR.

a. With the instrument turned on and the component adapter in place, plug in a capacitor of known value, approximately 1800 pF (a mica or polystyrene capacitor would be suitable).

b. Press pF switch.

c. Adjust R22 on Signal Conditioning Board No. 2 (figure 4-1) so that readout displays the known value.

NOTE

It is not necessary to perform this procedure in

this range. If another capacitor of known value is available with a value near the top of some other range, it may be used equally as well.

4-18. CONDUCTANCE-TO-DC CONVERTER OFFSET.

a. Plug input leads supplied with instrument into INPUT and COMMON jacks.

b. Press PWR ON switch.

c. Press nS switch and then left decimal switch.

d. With probes of leads not touching anything, adjust nS offset potentiometer on rear panel so that readout displays 0.00.

4-19. CONDUCTANCE-TO-DC CONVERTER SCALE FACTOR.

a. Using the input leads supplied with instrument, connect the INPUT and COMMON jacks to the resistance standard.

b. Set the standard to 6 MΩ.

c. Press PWR ON switch.

d. Press nS switch and then left decimal switch.

e. Adjust R15 on Signal Conditioning Board No. 3 (figure 4-1) so that readout displays 166.7.

4-20. °C-TO-DC CONVERTER OFFSET.

a. Using the input leads supplied with instrument, connect INPUT and COMMON jacks to output of DC voltage standard.

NOTE

The voltage standard must have a low enough output impedance so that the 100 μA output current from the TT-20 in this mode will not change the standard by more than 100 μV.

b. Set the standard to +598 mVDC. (Make sure the voltage is positive at the INPUT jack with respect to the COMMON jack.)

c. Press PWR ON switch.

d. Press °C switch.

e. Adjust R19 on Signal Conditioning Board No. 3 (figure 4-1) so that readout displays +025.

4-21. °F TO DC CONVERTER OFFSET.

a. Perform steps a, b and c under paragraph 4-20.

b. Press °F switch.

c. Adjust R5 on Signal Conditioning Board No. 3 (figure 4-1) so that readout displays +077.

NOTE

Since the temperature probes supplied with TT-20s are interchangeable, changing probes will not require recalibratiion.

SECTION V

MAINTENANCE

5-1. CLEANING.

5-2. The outer surface of the TT-20 will require cleaning from time to time. Use a soft cloth or brush dampened with a mild solution of detergent and lukewarm water. Be careful not to scratch the front panel especially in the display area. Since there are no ventilating holes in the case, the interior of the instrument probably will not require cleaning. However, in a dusty environment blow off the dirt accumulated inside the case with filtered compressed air. If this is not available, use a brush and vacuum cleaner. Use care not to upset the settings of the calibration potentiometers. If the above methods are not sufficiently effective, use a Freon(R) base solvent with a brush. Use the Freon very carefully near the front panel and the potentiometers on the rear panel. Freon will attack the plastic film on the front panel and the carbon elements of the potentiometers at the rear. Do not use a vapor degreaser on either the front or rear assemblies.

5-3. VISUAL INSPECTION.

5-4. After every few months of use visually inspect the multimeter for loose or broken connections, loose screws, heat-damaged components and if TT-20B, leaking batteries. Access to interior of instrument may be gained by removing screw on bottom of case and gently sliding chassis out of case. If anything improper is noted, the appropriate corrective action should be taken. In the case of overheated components, it is likely that the problem is not with the part that is overheated. When replacing an overheated component make sure the associated circuitry is functioning properly. Otherwise another overheated component may result.

5-5. TROUBLESHOOTING PROCEDURE.

5-6. Before attempting to troubleshoot the TT-20 make sure that any apparent trouble is actually due to a malfunction

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of the instrument rather than improper input connections, faulty offset adjustments, incorrect range or function selection, misinterpretation of the display, etc.

5-7. In using the following procedures, reference should be made to the theory of operation, with its simplified diagrams and logic tables, and the schematic diagrams located at the rear of this manual.

5-8. CIRCUIT TROUBLESHOOTING.

5-9. The TT-20 consists of five main circuit sections. These are:

a. Power Supply.

b. A/D Conversion and Display.

c. Range and Function Switching and Display.

d. Control Logic.

e. Input Signal Conditioning.

5-10. The first circuit to check for any type of trouble is the power supply. All other circuits in the instrument are dependent upon the proper operation of power supply circuitry. All the power supply voltages must be correct and should be measured first. If no problem is detected there, then the nature of the symptom should direct you to the circuit which contains the trouble. A sure way of confirming the location of trouble is by interchanging assemblies between one TT-20 and another, as the problem will follow the malfunctioning assembly.

CAUTION

Be certain power is off before removing any assembly from the instrument or plugging one into the instrument; damage may result.

5-11. TROUBLESHOOTING THE POWER SUPPLY.

5-12. The power source for the TT-20 is the wall-mounted transformer (charger unit). Its no-load output is approximately 12.5 VAC. With the instrument turned off and the tranformer plugged in, the voltage at the fuse on the rear board should measure +7.2 VDC. If the instrument is a TT-20B, this voltage will measure between + 6 VDC and +7.2 VDC until the batteries have been on charge for a few hours. If no problems have been encountered so far then the voltage source for the +5V regulator is probably satisfactory. To be sure, connect a load from the fuse to ground; the voltage should stay constant with anything up to a 300 mADC load.

5-13. The DC/DC converter is a self-oscillating circuit with the switching transistors operating alternately in the saturated mode. If the voltages across the output filter capacitors drop below 14 VDC, the converter is probably overloaded. Unplugging boards should locate the problem.

5-14. The +5 VDC regulator will automatically turn off if it is overloaded or if its input is less than +5.3 VDC. If unloading the regulator by unplugging boards and relays does not locate an overload, then look for shorted, leaky or open semiconductors in the regulator. If there is still no solution, the automatic shut-down circuit can be defeated by pressing the PWR ON switch continuously. Voltges can then be measured and the problem located.

5-15. TROUBLESHOOTING THE A/D CONVERTER AND DISPLAY.

5-16. Most of the A/D circuitry is contained in one integrated circuit (U1 in figure 3-1). To facilitate troubleshooting, this integrated circuit (IC) plugs in. Replacing this IC with a known good one generally cures problems in the A/D converter. The displays can be tested by disconnecting them and turning each segment "on" with a resistor and power supply combination (510Ω resistor in series with 5 VDC) to forward bias the LED with approximately 5 mADC. The reference regulator (VR2) can be tested by measuring the voltage across it (2.5V). The active filter will usually not affect the A/D converter unless by introducing leakage current. Disconnecting the filter capacitors will eliminate that possiblity. The polarity and decimal control is accomplished through logic-level gating and inverting. Signal tracing will pinpoint a problem here.

5-17. RANGE AND FUNCTION SWITCHING AND DISPLAY.

5-18. The front panel contains all of the range and function switches, and the function LED indicators. Unplug the assembly and test the switches with an ohmmeter. The LEDs can be tested by forward biasing them. (Refer to paragraph 5-15.)

5-19. TROUBLESHOOTING THE CONTROL LOGIC.

5-20. A problem in the control logic may be found by comparing the input versus output relationships of the logic as shown in tables 3-2 thru 3-4. To eliminate all loading effects on the logic, this test can be performed with only the front panel, main board and power supply assemblies connected.

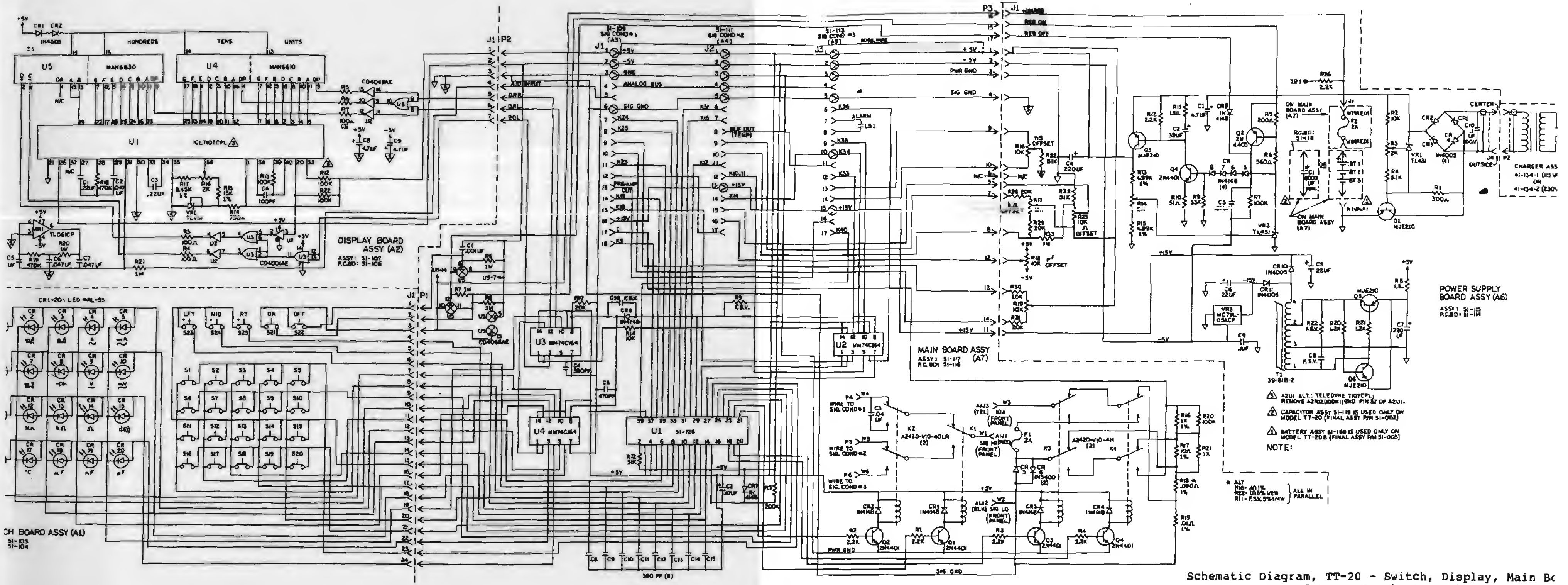
CAUTION

> To avoid damage to the Power Supply Assembly when operating the instrument without plug-in boards, a 1 kOhm-load resistor must be connected between the -15V and GND (pins 11 and 3 of the Power Supply Assembly).

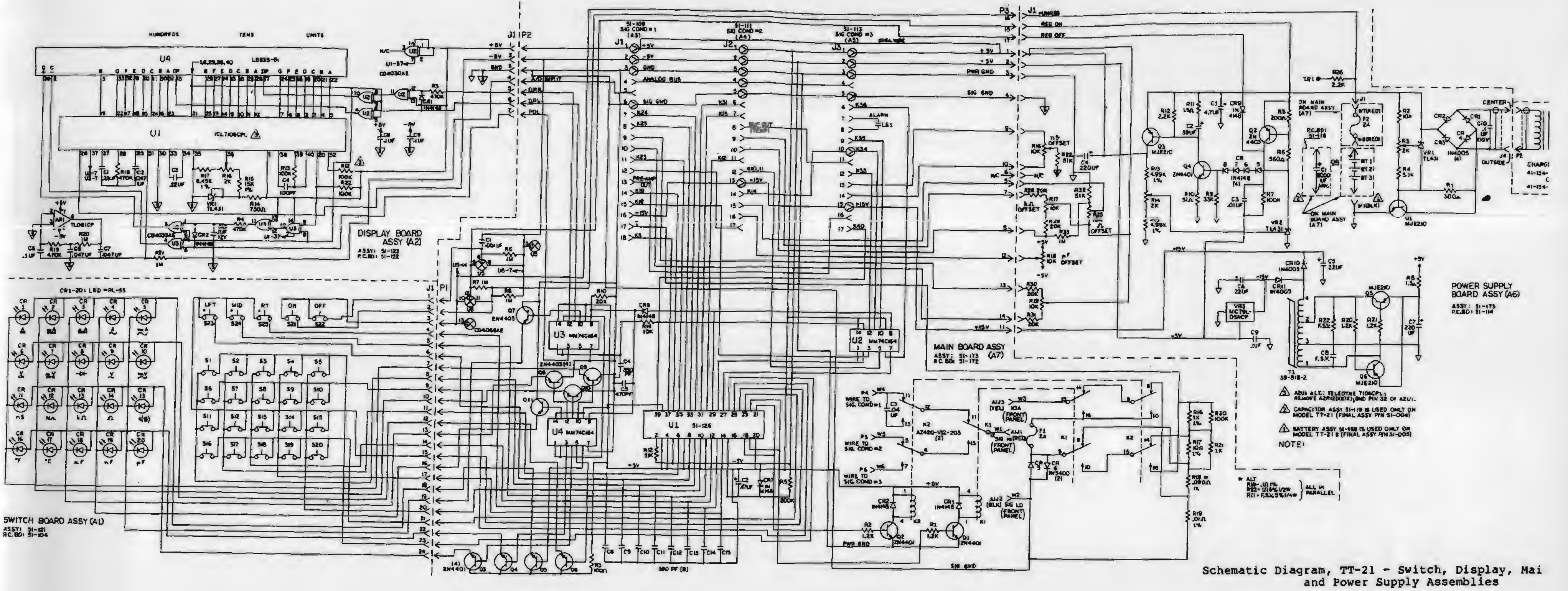
5-21. TROUBLESHOOTING THE INPUT SIGNAL CONDITIONING.

5-22. Input signal conditioning is performed for all functions except current on the three signal conditioning board assemblies. The current shunts are located on the main board assembly. Refer to the specifications and the theory of operation first to determine what the circuits are suppose to do and how they do it. Then trace the signal from the input terminals through the relays (metallic-contact and solid-state) through the amplifiers and into the A/D converter board. At some point the problem will become evident.

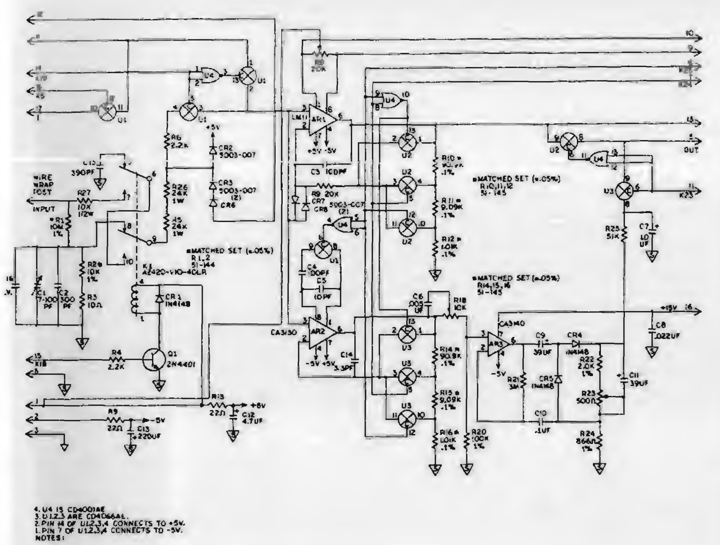
NOTES



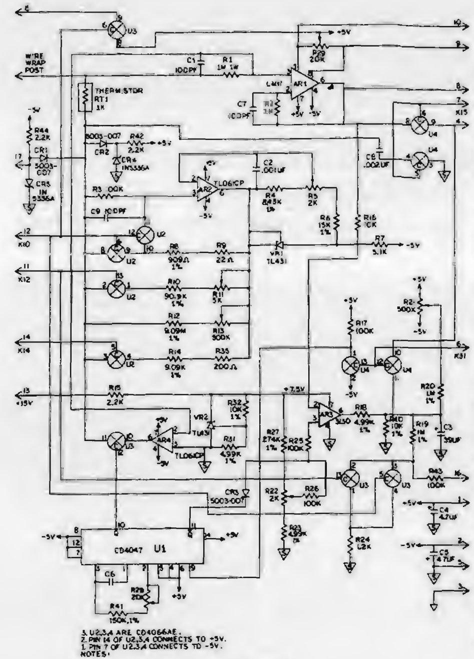
Schematic Diagram, TT-20 - Switch, Display, Main Bc
and Power Supply Assemblies



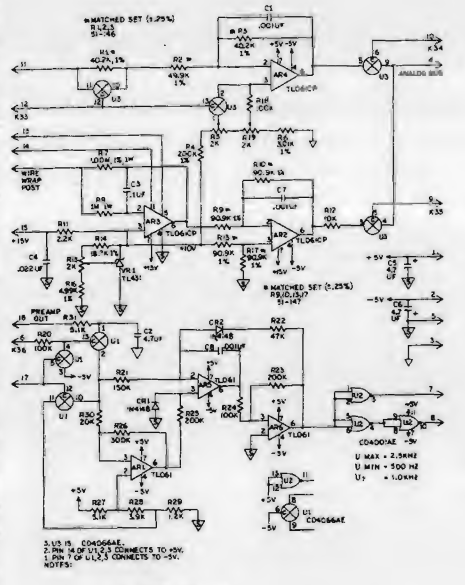
Schematic Diagram, TT-21 - Switch, Display, Mai
and Power Supply Assemblies



SIGNAL COND. NO. 1 (A3)
ASSY: 51-109
P.C.BD: 51-108



SIGNAL COND. NO. 2 (A4)
ASSY: 51-111
P.C.BD: 51-110



SIGNAL COND. NO. 3 (A5)
ASSY: 51-113
P.C.BD: 51-112

Schematic Diagrams - Signal Conditioning Assemblies

Limited Warranty

Non-Linear Systems, Inc. warrants each new instrument against defects in material or workmanship for a period of one year from date of delivery to the original customer. Fuses are excluded from this warranty and cathode-ray tubes are warranted for a period of ninety days only. This warranty is specifically limited to the replacement or repair of any such defects, without charge, when the complete instrument is returned to Non-Linear Systems, Inc., 533 Stevens Avenue, Solana Beach, California 92075, transportation charges prepaid. This express warranty excludes all other warranties, express or implied, and NON-LINEAR SYSTEMS, INC. IS NOT LIABLE FOR A BREACH OF WARRANTY IN AN AMOUNT EXCEEDING THE PURCHASE PRICE OF THE GOODS. NON-LINEAR SYSTEMS, INC. SHALL NOT BE LIABLE FOR INCIDENTAL OR CONSEQUENTIAL DAMAGES. No liability is assumed for damage due to accident, abuse, tampering with the instrument, lack of reasonable care, loss of parts or subjecting the instrument to input values of a magnitude in excess of those specified.